Dissociating Wanting and Anticipated Liking from Consummatory Liking in Smokers with Different Levels of Nicotine Dependence

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Abstract

Introduction: Incentive Sensitisation theory suggests wanting and liking are dissociable concepts, with wanting, but not liking typically increasing with repeated drug use. Wanting is associated with anticipation of reward, whereas liking relates to pleasure derived from consummatory behaviour. However, numerous studies have conceptualised liking as an anticipatory cognition. This study explores whether levels of nicotine dependence differentially effect wanting and liking responses to smoking-related cues, and whether anticipated and consummatory liking are equivalent, and dissociable from wanting.

Method: Heavy (HS, *M*=16 cigarettes/day) and light non-daily (LS, *M*=2 cigarettes/day) smokers completed wanting and anticipated liking questionnaires pre-, immediately post-exposure to smoking-related and neutral cues and at session-end. Consummatory liking was measured post-session, immediately after smoking.

Results: Wanting and anticipated liking responses were comparable. Smoking-related cues increased wanting and anticipated liking compared to neutral cues. This effect was maintained until session-end. No Baseline differences were seen between HS and LS on wanting or anticipated liking, however after cue exposure, and at session-end, HS reported greater drug wanting and anticipated liking than LS. Conversely, HS and LS did not differ on consummatory liking. Analyses confirmed the relationship between wanting and anticipated liking was significantly stronger than wanting and consummatory liking or anticipated and consummatory liking.

Conclusions: Wanting and anticipated liking appear to be overlapping constructs assessing expectations of reward, that are dissociable from consummatory liking. Furthermore, heavier smoking increases drug wanting, but not smoking pleasure. Future attempts to dissociate these concepts should ensure liking is measured during / immediately after consumption.

1. Introduction

The Incentive Sensitisation Theory (IST) of addiction suggests wanting and liking are separate and dissociable components of reward.[1,2] Wanting refers to incentive motivation and is associated with anticipation of reward (before reward intake), whereas liking relates to the hedonic impact of reward consumption (during or immediately after drug intake).[3] Wanting is suggested to increase with repeated drug use as a result of sensitisation of the mesocorticolimbic dopamine system. This renders the individual highly sensitive to drugs and their associated stimuli and results in excessive and irrational drug craving. A separate, more diffuse, neural system not mediated by dopamine is responsible for drug liking, and instead of increasing, remains stable or may desensitise with repeated drug use. The transition to addiction is therefore characterised by pathological drug craving, even in the absence of drug pleasure.[1,2]

The original assumptions of the IST were primarily based on evidence from rodent research, [e.g. 4] however, IST predictions have since been tested in humans to determine whether wanting and liking can be disentangled across reward-related behaviours such as problematic drug use [e.g. 5,6] and disordered eating. [e.g. 7,8] In pursuit of these answers, a diverse range of methods have been developed to assess and discriminate between these components of reward, including physiological and neurobiological measures, behavioural tasks and questionnaires (see [9] for a review of the methods used). The results have been inconclusive. One explanation for the mixed findings relates to the conceptualisation of liking as an anticipatory cognition, rather than a consummatory behaviour. Approximately 40% of studies reviewed by Pool and colleagues [9] assessed liking during or after exposure to reward-related cues, rather than during or after reward consumption. Furthermore, over 12% of the total sample phrased their assessment of liking to specifically measure expectations of pleasure in response to reward-related stimuli, for example 'How pleasant would it be to drink [it] [10] / taste some of this food now?'. [8]

Across the drug and food literature, a number of studies have measured wanting and *both* anticipated and consummatory liking [e.g. 11, 12], yet no explicit attempt has been made to assess the extent to which these different conceptualisations of liking are dissociable from wanting. The present study addressed this important issue by exploring whether anticipated and consummatory liking are equivalent, and separable from wanting in response to drug-related and neutral cues in a sample of cigarette smokers. To date, limited research has examined whether liking and wanting can be dissociated in smokers with varying results. Whilst greater wanting and decreased or comparable liking in dependant smokers compared to controls has been reported [e.g. 13], not all findings have been consistent with IST predictions. [e.g. 14 - 16] To further aid our understanding of the transition to nicotine dependence, the present study also compared levels of wanting and both anticipated and consummatory liking, between light and heavy smokers.

2. Method

2.1 Participants

Cigarette smokers were categorised into heavy smokers (HS) (*n* = 20; 10 female, mean age = 28.8 ± 12.8 years) and light smokers (LS) (*n* = 20; 13 female, mean age = 20.8 ± 3.5 years) based on the number of cigarettes smoked per day. HS smoked a minimum of 10 cigarettes daily and LS were non-daily smokers smoking on average 3.1 days a week. HS smoked more cigarettes per day than LS (mean = 15.8 ± 7.4 vs. 1.8 ± 1, $t_{19.72} = 8.4$, $P < .001$), were more dependent on nicotine based on their Fagerstrom Test of Nicotine Dependence (FTND) score (mean = 4.6 ± 2.3 vs. 0.1 ± 0.3, $t_{19.68} = 8.56$, $P < .001$) and had higher average baseline carbon monoxide levels (mean = 12.8 ± 5.2 vs. 2.5 ± 1.23, $t_{21.12} = 8.9$, $P < .001$). Participants were psychiatrically healthy, had no history of head injury and had not regularly used illegal drugs in the last six months. Participants were recruited from universities in Leeds and on www.gumtree.com/leeds. Participants were compensated with course credits (where applicable) or received £15. The study was approved by the ethics committee at Leeds Beckett University.

2.2 Materials and Procedure

This data forms part of a larger study examining the relationship between cue reactivity and impulsivity (data not presented here). Participants were screened via telephone and if eligible, sent a questionnaire pack including a smoking behaviours questionnaire and the FTND to assess typical smoking profiles. Participants completed two 1.5 hour experimental sessions; a smoking cue (SC) and a neutral cue (NC) session. Sessions were counterbalanced across participants and took place at the same time of day, commencing at 9am or 11am, at least two weeks apart and following ad libitum smoking. As expected, HS (SC – mean = 0.29 hours ± 0.29; NC – mean = 0.24 hours ± 0.29) had smoked more recently than LS (SC – mean = 50.23 hours ± 55.89; NC – mean = 70.78 ± 106.45) before both sessions ($F_{1, 38}$ = 13.206, *P* = .001), but importantly no differences were observed on time since last cigarette across cue conditions, and no within-group differences were observed on carbon monoxide levels across conditions. On arrival, participants completed BL measures of wanting and anticipated liking, followed by a secondary eligibility screening assessment to check carbon monoxide levels, time since last cigarette, and to ensure they had abstained from alcohol and caffeine for the required time. They were then connected to and familiarised with equipment measuring heart rate, skin conductance and blood pressure and asked to sit quietly and relax for 10 minutes to allow physiology to reach baseline levels. Baseline physiological responses were then recorded for six minutes. Following this, participants began the initial cue manipulation which lasted six minutes, during which they viewed and manipulated a packet of their preferred brand of cigarettes, a lighter and an ashtray (SC condition) or a box of pencils, rubber and notepad (NC condition). Physiological responses were recorded throughout (data not reported). Wanting and anticipated liking were measured immediately after (T1). Participants then completed five behavioural impulsivity tasks (duration approximately 45 minutes). The cue remained in sight throughout and was intermittently manipulated by the participant for one-minute intervals between tasks. Wanting and anticipated liking was measured again at the end of the session (T2). Consummatory liking was assessed immediately after participants smoked their first cigarette after the experimental session. Craving was also assessed at the same time points

using the Questionnaire of Smoking Behaviours-Brief (data not reported). Wanting was assessed through a single item 'How much do you want to smoke now?'. Single-item measures of craving have been found to be as sensitive and reliable as multi-item measures.[17] Anticipated liking was measured with three items 'How satisfying/pleasurable/rewarding do you expect it would be to smoke a cigarette now?'. Consummatory liking asked 'How satisfying/pleasurable/rewarding was it to smoke that cigarette? All answers were recorded on a 0-100 VAS (0=not at all, 100=extremely).

2.3 Data Reduction and Statistical Analysis

The three items assessing liking were highly intercorrelated (all *r*'s >.9) and therefore combined into two composite anticipated and consummatory liking scores based on a mean of the three scores for each participant, for subsequent analyses. The parametric wanting and anticipated liking data were analysed in separate three-way ANOVAs with smoking group (HS, LS) as a between-subjects factor, and cue type (SC, NC) and time (BL, T1, T2) as within-subjects factors. Consummatory liking was assessed with a two (group) x two (cue) mixed ANOVA. Data from all smokers were combined to perform bivariate correlations which explored the strength of the interrelationships between wanting, anticipated and consummatory liking at each time point and cue condition. Fisher's *Z* transformation assessed the significance of the difference between pairs of correlation coefficients. Data are reported as significant at the .05 level.

3. Results

3.1 Wanting

Significant main effects of cue ($F_{1,38}$ = 7.22, P = .01, η_p^2=0.16), group ($F_{1,38}$ = 6.89, P = .01, η_p^2 = 0.15) and time ($F_{1.58,60.02}$ = 61.72, P < .001, η_p^2 = 0.62) were revealed on wanting, and significant cue x time ($F_{1.73,65.65}$ = 8.42, P = .001, η_p^2=0.18) and group x time ($F_{2,76}$ = 8.46, P = .001, η_p^2=0.18) interactions. No other interactions reached significance (all *ps* > .75). Exploration of the cue x time interaction indicated no cue differences at BL (P = .91), however at T1 (immediately after cue exposure) (P < .001) and T2

(end of session) (*P* = .02), wanting was significantly greater in response to the SC compared to the NC. Furthermore, in the NC condition, wanting significantly increased from BL to T1 (*P* = .001), BL to T2 (*P* < .001) and T1 to T2 (*P* = .002), whereas in the SC condition wanting increased from BL to T1 and BL to T2 (all *P*s < .001) but was stable between T1 and T2 (*P* >.99), (Figure 1a).

Exploration of the group x time interaction revealed no group differences at BL (*P* = .9), however, at T1 (*P* = .04) and T2 (*P* = .001), HS reported significantly greater wanting than LS. In addition, in LS, wanting increased from BL to T1 and BL to T2 (all *Ps* < .001), but stabilised between T1 and T2 (*P* > .99), however, in HS wanting increased from BL to T1 and BL to T2 (all *Ps* < .001) and T1 to T2 (*P* = .001) (Figure 1c) (see Supplementary Materials, Table S1 for descriptive statistics for Wanting).

3.2 Anticipated liking

In an identical pattern to wanting, significant main effects of cue ($F_{1,38}$ = 8.18, *P* = .01, η_p^2 = 0.18), group ($F_{1,38}$ = 7.36, *P* = .01, η_p^2 = 0.16) and time ($F_{1.5,56.98}$ = 49.83, *P* < .001, η_p^2 = 0.57) were revealed on anticipated liking, and significant cue x time ($F_{1.58,60.14}$ = 5.16, *P* = .01, η_p^2 = 0.12) and time x group ($F_{2,76}$ = 6.11, *P* = .003, η_p^2 = 0.14) interactions. Remaining interactions were non-significant (all *Ps* > .71). Exploration of the cue x time interaction revealed greater anticipated liking after the SC compared to the NC at T1 (*P* = .001) and T2 (*P* = .004) but no difference at BL (*P* = .51). In addition, in the NC condition, anticipated liking increased from BL to T1 (*P* = .01), BL to T2 (*P* < .001) and T1 to T2 (*P* = .001), however, in the SC condition, it increased from BL to T1 and BL to T2 (all *P*s <.001) with no significant increase between T1 and T2 (*P* = .44) (Figure 1b).

Analysis of the group x time interaction indicated no group differences at BL (*P* = .1), however at T1 (*P* = .008) and T2 (*P* = .003) anticipated liking was significantly greater in HS than LS. Furthermore, in LS anticipated liking increased from BL to T1 (*P* = .001) and BL to T2 (*P* < .001) and was stable between

T1 and T2 (P = .6), however in HS it increased from BL to T1 and BL to T2 (all Ps < .001) and T1 to T2 (p = .01) (Figure 1d).

3.3 Consummatory liking

No significant main effect of cue ($F_{1,34}$ = 3.3, P = .08, η_p^2 = 0.09), group ($F_{1,34}$ = 3.95, P = .06, η_p^2 = 0.1), and no cue x group ($F_{1,34}$ = 0.32, P = .58, η_p^2 = 0.01) interaction was observed on consummatory liking (Figure 1e).

See Supplementary Materials, Tables S1 - S3 for additional descriptive statistics relating to Wanting, Anticipated Liking and Consummatory Liking.

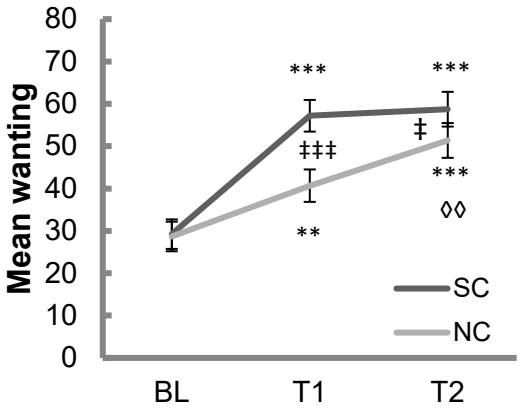

Figure 1a. Wanting significant cue x time interaction

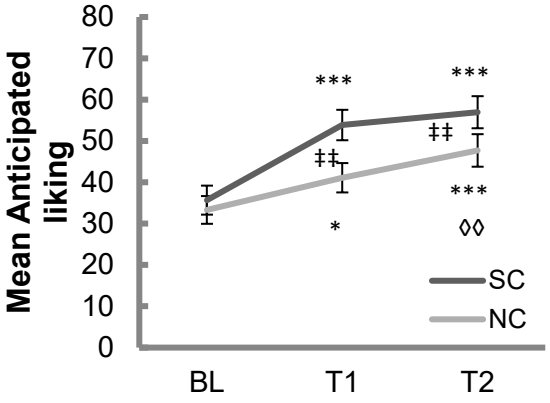

Figure 1b. Anticipated liking significant cue x time interaction

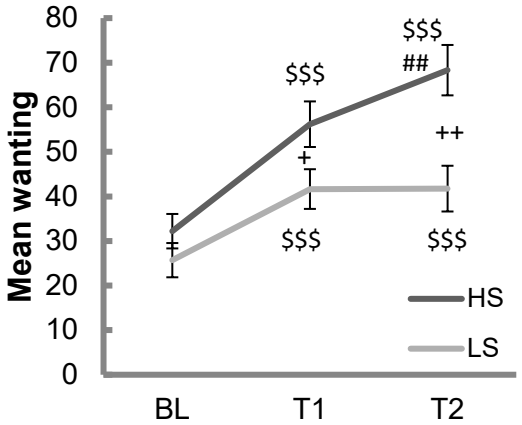

Figure 1c. Wanting significant group x time interaction

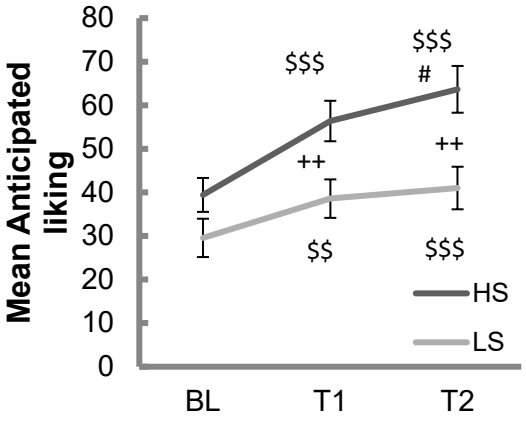

Figure 1d. Anticipated liking significant group x time interaction

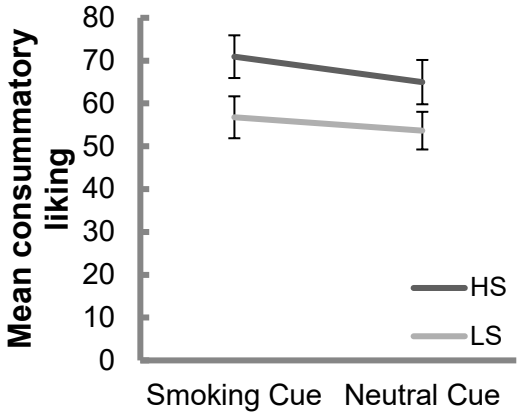

Figure 1e Consummatory Liking non-significant cue x group interaction

Figure 1(a-d) Wanting and anticipated liking significant interactions: Each line represents mean wanting or anticipated liking score ±SEM. Bonferroni comparisons made for within-subjects time factor.
***$P < .001$; **$P < .01$; *$P < .05$ sig. diff from BL on same cue; $^{◊◊◊}P < .001$; $^{◊◊}P < .01$; $^{◊}P < .05$ sig. diff from T1 on same cue; $^{‡‡‡}P < .001$; $^{‡‡}P < .01$; $^{‡}P < .05$ sig. diff from NC at same time point; $^{\$\$\$}P < .001$; $^{\$\$}P < .01$; $^{\$}P < .05$ sig. diff from BL in same group; $^{\#\#\#}P < .001$; $^{\#\#}P < .01$; $^{\#}P < .05$ sig. diff from T1 in same group; $^{+++}P < .001$; $^{++}P < .01$, $^{+}P < .05$ sig. different from HS at same time point.
Figure 1 (e) Consummatory liking non-significant cue x group interaction.
Consummatory liking data was not returned in one or both cue conditions by three HS and one LS, leaving 17 HS and 19 LS in the analysis.

3.4 Interrelationships and Correlation Strength Comparisons

Bivariate correlations assessed the strength of the interrelationships between wanting, anticipated and consummatory liking, then Fisher's Z transformation determined the significance of the difference between the pairs of correlation coefficients. Table 1 shows that at each time point in both cue conditions, the relationship between wanting and anticipated liking was significantly stronger than the relationship between wanting and consummatory liking or anticipated and consummatory liking. No significant difference was observed between wanting and consummatory liking and anticipated and consummatory liking at any time point or in any cue condition.

Table 1. *Interrelationships between Wanting, Anticipated Liking and Consummatory Liking and Correlation Coefficient Strength Comparisons*

	Pair	Variable 1	Variable 2	*r*	n	Comparison of *r* coefficients	Fisher's *Z*
BL SC	a	Wanting	Anticipated Liking	.881	40	vs. Pair b	3.48***
	b	Wanting	Consummatory Liking	.507	38	vs. Pair c	-0.58
	c	Anticipated Liking	Consummatory Liking	.602	38	vs. Pair a	2.9**
T1 SC	a	Wanting	Anticipated Liking	.903	40	vs. Pair b	2.28*
	b	Wanting	Consummatory Liking	.740	38	vs. Pair c	0.22
	c	Anticipated Liking	Consummatory Liking	.715	38	vs. Pair a	2.51*
T2 SC	a	Wanting	Anticipated Liking	.948	40	vs. Pair b	2.7**
	b	Wanting	Consummatory Liking	.826	38	vs. Pair c	-0.18
	c	Anticipated Liking	Consummatory Liking	.839	38	vs. Pair a	2.52*
BL NC	a	Wanting	Anticipated Liking	.861	40	vs. Pair b	3.46***
	b	Wanting	Consummatory Liking	.438	36	vs. Pair c	-0.62
	c	Anticipated Liking	Consummatory Liking	.552	36	vs. Pair a	2.82**
T1 NC	a	Wanting	Anticipated Liking	.955	40	vs. Pair b	4.49***
	b	Wanting	Consummatory Liking	.670	36	vs. Pair c	-0.72
	c	Anticipated Liking	Consummatory Liking	.756	36	vs. Pair a	3.75***
T2 NC	a	Wanting	Anticipated Liking	.930	40	vs. Pair b	3.65***
	b	Wanting	Consummatory Liking	.655	36	vs. Pair c	-0.80
	c	Anticipated Liking	Consummatory Liking	.753	36	vs. Pair a	2.83**

Abbreviation: BL = baseline, T = time, SC = Smoking Cue; NC = Neutral Cue; n = number; *r* = Pearson's Correlation Coefficient

***$P < .001$, **$P < 0.01$, *$P < .05$

4. Discussion

Irrespective of smoking group, exposure to smoking-related cues increased drug wanting and anticipated liking in comparison to neutral cue exposure, and to baseline, and this effect was maintained until the end of the session, suggesting that drug-related cues are effective in generating and sustaining craving in all smokers. The increase in wanting and anticipated liking over time in response to neutral cue exposure may reflect craving induced either by abstinence or experimental demands of a 1.5 hour session.

Consistent with IST predictions [1], data suggested that wanting was dissociable from consummatory liking, but not from anticipated liking, as heavy smokers reported higher levels of wanting and anticipated liking, but not consummatory liking, relative to light smokers. Therefore, the transition to nicotine dependence appears to be marked by a strong desire to smoke, with an expectation of pleasure, but no heightened enjoyment from the consummatory act. That these effects were not qualified by cue condition was unexpected, but suggests contrasts between liking and wanting in HS and LS may be similar in response to both smoking cues and in the neutral cue condition, where abstinence / experimental demand may play a role.

Crucially, wanting and anticipated liking showed identical patterns of results in heavy and light smokers in response to drug-related and neutral cues over the three assessment points and were significantly more strongly correlated with each other than wanting and consummatory liking or anticipated and consummatory liking. This suggests that anticipated liking may not be equivalent to consummatory liking, but may instead tap into anticipatory cognitions and cognitive desires for rewards which are indistinguishable from self-reported wanting. Assessing anticipation of pleasure rather than consummatory pleasure when testing the IS theory can be problematic because it relies on reconstruction of memories related to past hedonic experiences which can be distorted, leading to erroneous/inaccurate predictions about future hedonic experiences [18] and thus introduces a potential source of confound into this field, as discussed by Pool and colleagues. [9]

It is important to consider that some elements of wanting and liking may be operating at an unconscious level [19] and as such self-report measures may not be best-placed to capture these constructs. To circumvent these issues, indirect measures such as the Implicit Association Task (IAT) have been developed to assess these constructs and whilst the validity of early versions of this measure have been questioned [20], a more recently developed Wanting-IAT appears promising. [13] Furthermore, as our interest was in capturing consummatory liking when participants naturally chose to smoke, time to first cigarette after the session was not standardised. Although no differences in time to first cigarette were seen across cue conditions, as expected heavy smokers smoked their first cigarette significantly faster than light smokers. It is not known if assessing consummatory liking at a standardised point in close proximity to the end of the session, would create different results. Future studies may consider exploring these issues.

In conclusion, it is imperative that future attempts to dissociate wanting and liking using self-report measures consider how and when liking is measured to ensure that it does not deviate from its original conceptualisation as a consummatory response measured during, or immediately after, reward intake.

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